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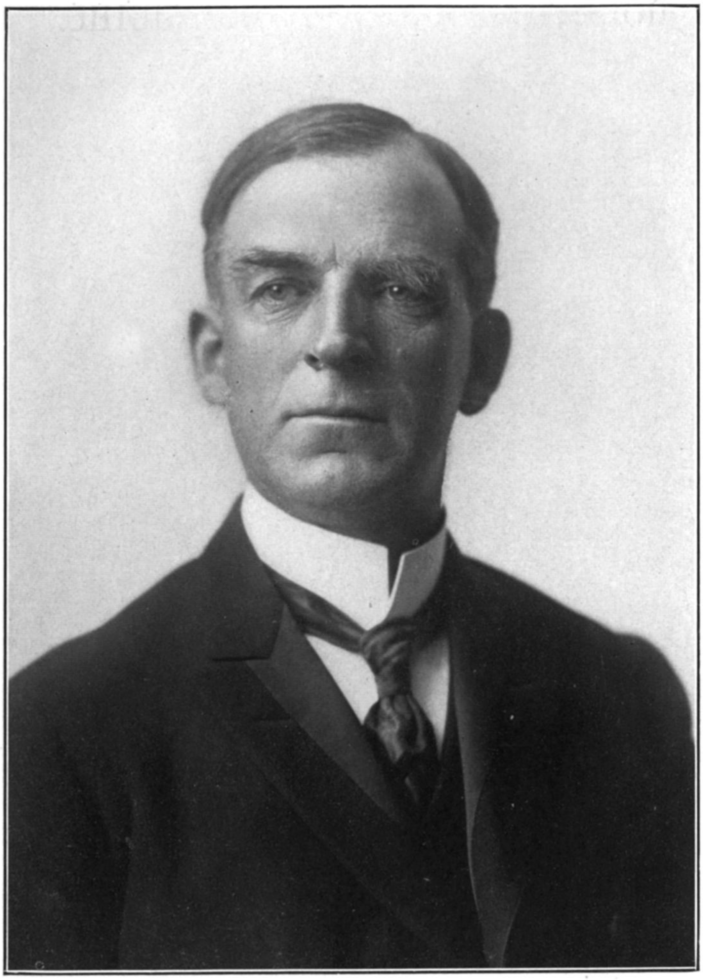

WILLIAM WALLACE CAMPBELL.

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# ADDRESS UPON THE PRESENTATION OF THE BRUCE GOLD MEDAL TO DR. W. W. CAMPBELL.[1]

By Russell Tracy Crawford.

"Every career has its aspirants, who pay their respects to those who have reached the goal." And so we are gathered here on this occasion to pay our respects to one who has reached a place among the eminent in astronomy. The Bruce Gold medal is awarded by this Society for "distinguished services to astronomy," and the statutes relating to its bestowal require that, at the presentation, an account shall be rendered of these distinguished services. That Dr. Campbell has rendered such services no one the least conversant with the science of astronomy will question. If, perchance, there should be a doubter, I advise such a one to read our Medalist's recent book, "Stellar Motions," and "forever after hold his peace." Therein is to be found a wealth of material and deductions from his years of work with the spectrograph, a most powerful instrument in his hands.

"Success," wrote Victor Hugo, "is a very hideous thing, and its resemblance with merit deceives men." In the award of the Bruce Gold Medal deceit can play no part, as can be realized when the method of making the selection of medalist is known. Here success and merit must go hand in hand. You may be sure that anyone who attains success thru anything but merit can never receive this medal.

To Dr. Campbell have been awarded four other medals, viz., the Lalande in 1903, the Royal Astronomical Society in 1906, the Draper in 1906, and the Janssen in 1910. The address of President W. H. MAW in awarding the Gold Medal of the Royal Astronomical Society is an excellent account of our Medalist's distinguished services up to 1906. In my account I shall, therefore, simply summarize what President MAW has said so well, and dwell in particular only on matters that have been developed since 1906.

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[1] Delivered at the joint meeting of the American Astronomical Society and the Astronomical Society of the Pacific, at Berkeley, Tuesday afternoon, August 3, 1915.

First and foremost are mentioned Dr. CAMPBELL'S determinations of stellar velocities in the line of sight, and his work on spectroscopic binaries. He is easily recognized as a leader in these investigations. The improvements and refinements made in the spectrograph by himself and his colleagues have led to such a degree of accuracy in his radial velocity determinations that Dr. CAMPBELL has been able to detect a variation of velocity with the Mills' spectrograph of an amount smaller than the probable error of a determination with most other instruments. President MAW says in this connection, "The development of this branch of spectroscopic astronomy has thus only been secured by the gradual introduction of various instrumental refinements, combined with the recognition of the sources of error, and the exercise on the part of the observers of care and skill of the very highest order."

In April, 1905, Dr. CAMPBELL issued his first catalog of spectroscopic binaries. In the words of President MAW, "a catalog which is in itself ample evidence of the importance of the work done by our Medalist."

By February, 1906, the radial velocities had been determined of about 500 stars at the Lick Observatory, and of about 200 stars at the D. O. Mills Observatory in Chile. "The whole of this extensive and most important work has been inaugurated by our Medalist, and carried out—much of it by himself—in accordance with the program he had drawn up," writes Dr. MAW. And I may add that to date this output has been practically doubled.

An interesting by-product of this work was Dr. CAMPBELL'S discovery in August, 1899, of the triple character of *Polaris*.

One of the several problems Dr. CAMPBELL had set for solution in connection with his radial velocity work is that of finding the Sun's way. In 1901 he had the results from 280 stars with which to make a first rough determination. He found the Sun to be traveling with a velocity of 19.9 kilometers per second toward the point in the sky $\alpha = 277^\circ.5$ and $\delta = +20^\circ$. This declination differs about 15° from that ascribed by NEWCOMB. Dr. CAMPBELL attributed this to the fact that his stars were not uniformly enuf distributed over the sky. He then realized that he must have the radial velocities of stars in the southern hemisphere which could not be reached from the Lick Observatory. This led him to the establishment of the D. O. Mills Observatory in Santiago, Chile. "The organization of this expedition, says President MAW, "may well be cited as a splendid example of the thoroness and vigor with which our Medalist attacked an important problem." In 1910 he had available the results from 1047 stars fairly well distributed with respect to the two hemispheres from which he deduced a velocity of $-17.77$ kilometers per second toward the point $\alpha = 272^\circ\ 0'$, $\delta = +27^\circ\ 26'$. In March, 1911, the elements of the solar motion were re-determined according to a rather extensive program. (Cf. *Stellar Motions*, pg. 209.) Based upon 1193 stars, $V_0 = -19.5^{\mathrm{km}}$, $\alpha = 268^\circ.5$, $\delta = +25^\circ.3$. From his various solutions wherein the stars were grouped according to spectral type Dr. CAMPBELL concludes, "The resulting velocity of the solar motion, $V_0$, appears to be a function of the spectral class of the stars upon which it rests, at least as far as the brighter stars are concerned."

Another interesting result from these investigations is the relation between the velocity of a star in space and its brightness. Of Dr. CAMPBELL'S earlier work President MAW calls attention to his investigations of the Wolf-Rayet stars, and numerous spectroscopic results of minor importance.

To organize and carry thru to a successful conclusion an eclipse expedition requires a mind that, like the chess master's can see many moves ahead. Dr. CAMPBELL'S experiences on numerous journeys to observe eclipses have now put him into a position to organize such an expedition so that every screw, nail, board, lens, can of meat, or anything else that may be needed is fully provided for; just what is necessary, and nothing that is not necessary. When one reads his charming account of the expedition to Flint Island one realizes how very much of the success of eclipse observing is due to this genius for organization. Those who have been fortunate enuf to hear our Medalist lecture about such an expedition have been presented with many interesting side-lights concerning them which bring out, even more clearly than his written accounts, his forethought in planning and resourcefulness in carrying out his program. In addition to this power of organization there stand to his credit many ingenious arrangements for observing eclipses. To quote again from President MAW, "It is, in fact, impossible to overrate the importance of the influence which our Medalist has exercised on the eclipse expeditions which have during recent years been sent out from the Lick Observatory; and probably only those who have taken part in such expeditions can fully appreciate his powers of organization, and his skill and resourcefulness in devising special lines of research and instrumental means for rendering such researches practicable."

President MAW calls attention to our Medalist's researches in the spectra of nebulæ, the orbit and parallax of *Sirius*, spectra of comets, and spectroscopic characteristics of temporary stars.

One of our Medalist's greatest contributions to the cause of science is in his upsetting the old idea that, as Sir G. H. DARWIN stated, "A mere catalog of facts, however well arranged, has never led to any important scientific generalization." This theme has been so well developed by Professor TURNER in his Presidential Address[1] before the B. A. A. S. in 1911 that I shall not dwell further on it here.

When Dr. CAMPBELL commenced his wonderful series of observations for radial velocities he had in mind the solution of four or five definite problems. But he never dreamed, I am sure, that they would ultimately lead him to make the astounding discovery that the older a star is, the greater is its speed. Of this Professor EDDINGTON writes, "We may well regard this relation of age and velocity as one of the most startling results of modern astronomy."

Averaging the velocities of stars of the same spectral type (according to SECCHI's classification), Dr. CAMPBELL found this progression and announced it in the Silliman lecture of

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[1] *Science*, Sept. 15, 1911.

January 31, 1910. His words are,[1] "The progression of average velocity with advancing spectral type is clear and unmistakable." Then to be more convincing he tells us that,[2] "Returning to Mount Hamilton on February 24, 1910, I had the velocities with reference to the stellar system tabulated on the basis of the Harvard classification of spectra, as follows:—

| Spectral Classes. | Number of Stars. | Average Radial Velocities. |
|---|---|---|
| O and B | 141 | 8.99$^{km}$ |
| A | 133 | 9.94 |
| F | 159 | 13.90 |
| G and K | 529 | 15.15 |
| M | 72 | 16.55 |
| Nebulæ (KEELER) | 13 | 23.4 |

The increase of stellar velocity with advancing type was seen to hold on the Harvard classification, as well as for the Secchi classification upon which the discovery had been made.

It was a surprise to find the average velocity of the thirteen nebulæ, as observed by KEELER, in excess of the averages for the stellar spectral types. This may or may not indicate that the number of nebulæ available is too small to serve as a basis for averages. If from the list of thirteen nebulæ we remove the *Orion* nebulæ, which has radial velocity nearly zero, the average residual radial velocity for the remaining twelve nebulæ is in excess of 25$^{km}$. Here we may have evidence of great strength and importance in support of a hypothesis that the planetary nebulæ have been formed from stars thru processes arising from collisions with or close approaches to other massive bodies. The zero velocity of the *Great Nebula in Orion* is not out of harmony with the hypothesis."

This startling and important discovery has made necessary a reorganization of the lines of thought in stellar evolution and cosmogony. Its effects are far-reaching.

DARWIN demanded, as Professor TURNER points out, a theory as a necessity for the advance of science. Here, however, we have a weighty advance of science and no theory. A theory is now to be sought to account for the observed fact. I am sure Dr. CAMPBELL thinks he has advanced no theory, but a reading of his *Stellar Motions* will show that he is not lacking in ideas on the subject, as he naïvely asks a few pertinent questions. Let me quote his words,[1] "It is not easy to explain why the velocities of stars should increase with their effective ages, for we are accustomed to think of all matter as equally old gravitationally. Why should not the materials composing a nebula or a Class B star have been acted upon by gravitational forces as long and as effectively as the materials in the Class M stars? Are stellar materials in the ante-stellar state subject to NEWTON'S law of gravitation? Does gravitation become effective only after the processes of combination are well under way? Is it possible that the gaseous matter composing a nebula is acted upon as effectively by radiation pressure as by gravitational attraction? The observed fact of the dependence of stellar velocity upon the spectral class is so new that these comments and questions make no pretentions to the status of a solution; but I am unable to suggest any other directions in which we should seek for the explanation."

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[1] CAMPBELL, *Stellar Motions*, page 206.
[2] *Ibid.*, page 207.

Another interesting and important result that our Medalist has arrived at, based upon his valuable radial velocity data, is the relation between the distances of the components of a binary system, the eccentricities of their orbits, and their age. "A study of the orbits of spectroscopic binary stars has established that the component stars in a system whose spectrum indicates early age are relatively very close together, requiring very short periods of revolution, and that the orbits are nearly circular. In systems whose spectra show them to be of greater effective ages, the distances separating the components are successively greater, on the average, and their orbits are more eccentric. The observed facts on the subject are fully confirmative of existing mathematical theories of the evolution of double star systems."

In discussing the question of parallax and proper motion as related to spectral types Dr. CAMPBELL comes to the conclusion, "That the scale on which the universe of brighter stars is constructed is apparently a great deal larger than we had supposed." And thus he enlarges our horizon, so to speak, and calls attention to the urgent need of still more radial velocity determinations to help in the solution of the many great problems relating to the stellar universe, not a few of which, I may add, owe their inception to the genius of our Medalist.

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[1] *Stellar Motions*, page 216.

In pleading for further observations he also urges the attainment of greater accuracy. In this connection he opens our eyes in regard to the character of our stellar neighbors, pointing out that it is quite probable that our system of one large central body attended by several very small masses is an exception, and not the prevailing type of system. If an accuracy could be attained which would reveal a variation of $0.03^{km}$ per second, the variation of speed of the Sun about the center of gravity of the solar system could be observed by an observer on another system. To quote from *Stellar Motions,* pg. 281, "An observer, favorably situated in another system, provided with instruments enabling him to measure speeds with absolute accuracy, could detect this variation, and in time say that our star is attended by planets. . . . As the accuracy attainable improves with experience, the proportional number of spectroscopic binaries discovered will undoubtedly be enormously increased. There is a possibility that the stars attended by massive companions, rather than by small planets only, are in a decided majority; . . . This is not a casual and passing comment. We do not possess a shred of positive evidence that any other star than our own is attended by small planets: we seem powerless at present to obtain any evidence in favor of or against their existence; and the prevailing belief that planets exist in other systems rests upon analogy to the solar system. We *have* the evidence of visual and spectroscopic binary stars that other systems with two or more massive central bodies are extremely common."

In his book *Germany and the Germans,* PRICE COLLIER has written, "The real test of successful organization is the thoroness of the thinking behind it; on the other hand, the only test of the thinking is the success of the thought in actual execution." When we consider the eminently successful work turned out from the Lick Observatory we have before us the evidence that our Medalist has rendered distinguished services to astronomy not only as a scientist, but also as a capable director of a great observatory. Too often the taking over of executive responsibilities has been a detrimental handicap to the individual scientist. Happily this has not been the case with our Medalist. VICTOR HUGO speaks of "a contagion of idleness." There is also a contagion of activity. And so Dr. CAMPBELL has rendered further great services to astronomy in the inspiration he has imparted to those working with him.

In his Sigma Xi address at the University of Illinois, delivered May 4th of this year, Professor GEORGE OTIS SMITH says, "A statesman is defined as a politician who has died. . . . Too often we are tardy in our recognition of the worth of men and also of the significance of events." Fortunately we, today, are not too tardy in our recognition of the worth of our Medalist. And I know that it is a matter of deep gratification to us all that we are gathered here to pay our respects to him.

Dr. WILLIAM WALLACE CAMPBELL, Director of the Lick Observatory, efficient executive, great astronomer, eminent scientist, it is with greatest pleasure that, on behalf of the Astronomical Society of the Pacific, I now present to you this beautiful medal with full knowledge that the Society, in thus honoring you is honoring itself in inscribing your name on the roll of illustrious recipients of the Bruce Gold Medal.